US005802545A

United States Patent [19]

Coverdill

[11] Patent Number: 5,802,545

[45] Date of Patent: Sep. 1, 1998

[54] **METHOD AND SYSTEM FOR RECORDING VEHICLE DATA RELATIVE TO VEHICLE STANDARD TIME**

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[73] Assignee: **Freightliner Corporation**, Portland, Oreg.

[21] Appl. No.: **652,776**

[22] Filed: **May 23, 1996**

[51] **Int. Cl.**[6] **G06F 17/00**

[52] **U.S. Cl.** **711/35**

[58] **Field of Search** 364/550, 551.01; 340/458; 711/35, 29

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,258,421	3/1981	Juhasz et al.	364/424.04
4,533,962	8/1985	Decker et al.	360/5
5,173,856	12/1992	Purnell et al.	364/424.04
5,250,761	10/1993	Koyanagi	364/424.04
5,253,224	10/1993	Van Doesburg	364/424.04
5,303,163	4/1994	Ebaugh et al.	364/550
5,452,446	9/1995	Johnson	364/424.04
5,526,269	6/1996	Ishibashi et al.	364/424.04
5,594,646	1/1997	Itoh et al.	364/424.04
5,600,558	2/1997	Mearek et al.	364/424.04
5,650,930	7/1997	Hagenbuch	364/424.04

OTHER PUBLICATIONS

Owner's Manual Caterpillar Driver Information Display, Caterpillar, Feb., 1995.

ProDriver™ User Manual, Detroit Diesel Corporation, Mar., 1994.

CELECT RoadRelay™ User's Guide, Cummins Cadec, No Date.

Primary Examiner—Vincent N. Trans

Attorney, Agent, or Firm—Klarquist Sparkman Campbell Leigh & Whinston LLP

[57] **ABSTRACT**

A master clock on a truck maintains vehicle standard time for the purposes of monitoring and recording vehicle performance data throughout the vehicle. Vehicle performance data is stored for a predefined period of time in response to detecting predefined events. Instances of vehicle performance data is time stamped with vehicle standard time. The master vehicle clock can also maintain the local time displayed to the driver. In response to inputs from the driver, the difference between driver local time and vehicle standard time is computed and the updated local time is displayed to the driver.

23 Claims, 7 Drawing Sheets

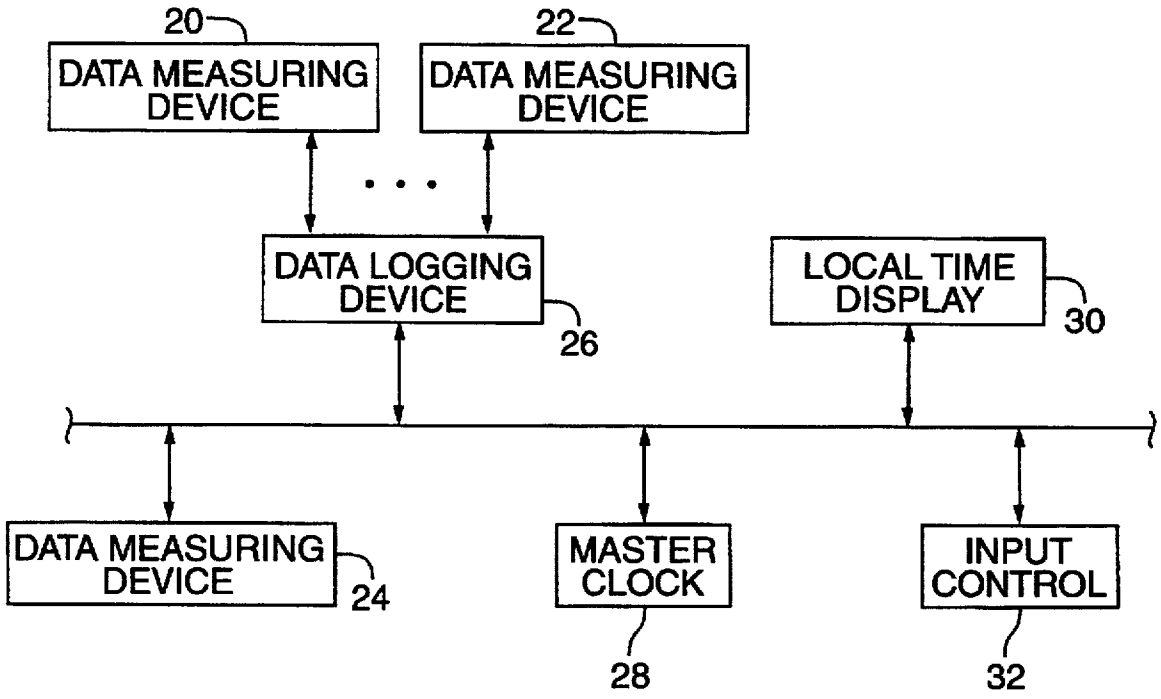
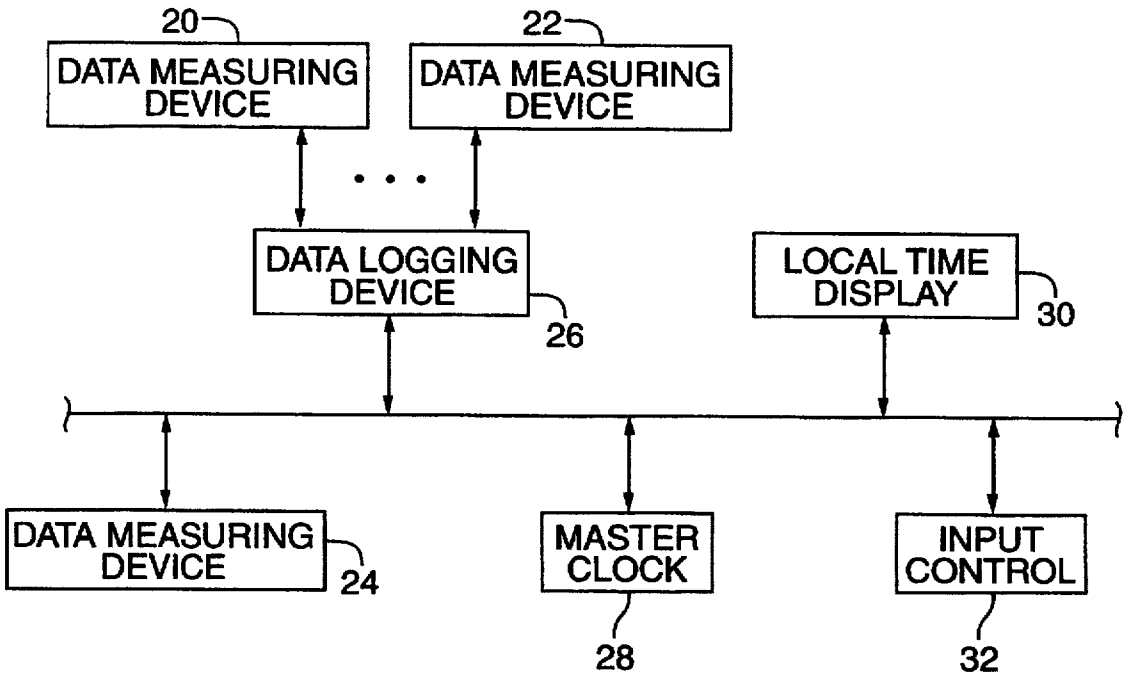


FIG. 1


20
22
DATA MEASURING DEVICE
DATA MEASURING DEVICE
DATA LOGGING DEVICE
26
LOCAL TIME DISPLAY
30
DATA MEASURING DEVICE
24
MASTER CLOCK
28
INPUT CONTROL
32

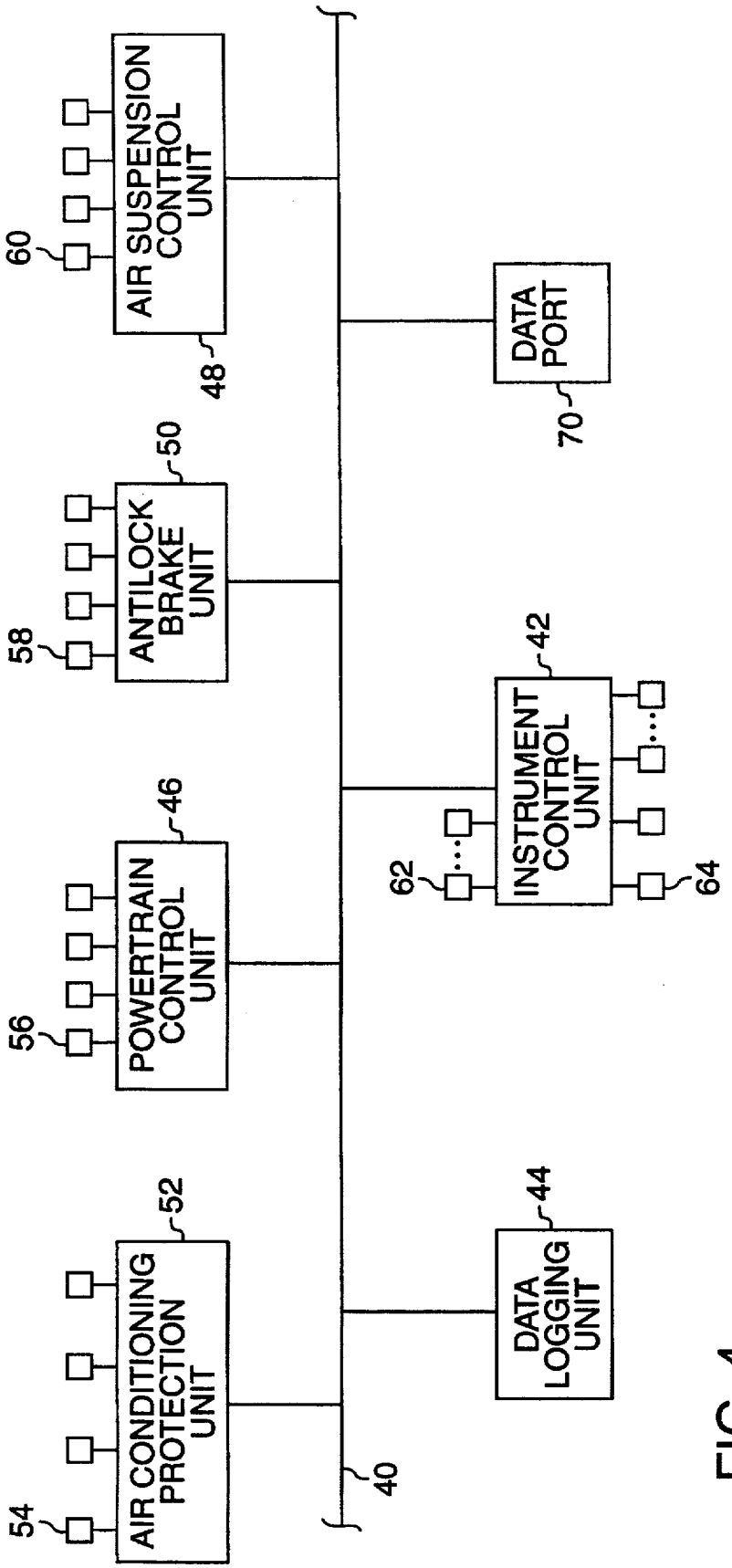

AIR CONDITIONING PROTECTION UNIT
52
54
POWERTRAIN CONTROL UNIT
46
56
ANTILOCK BRAKE UNIT
50
58
AIR SUSPENSION CONTROL UNIT
48
60
DATA LOGGING UNIT
44
DATA PORT
70
INSTRUMENT CONTROL UNIT
42
62
64
40

FIG. 2

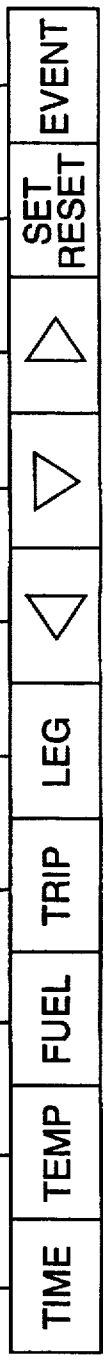
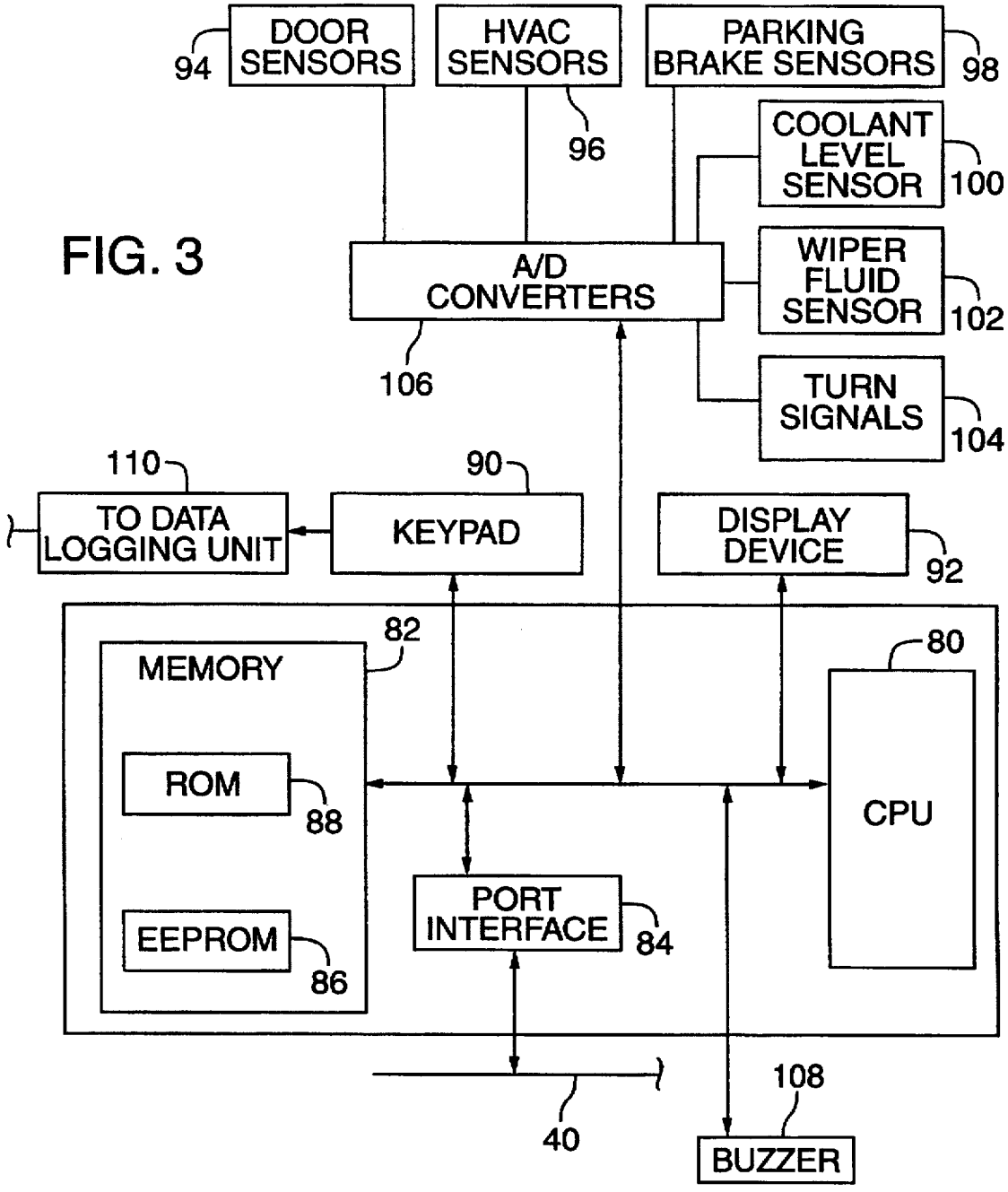

TIME
120
TEMP
122
FUEL
124
TRIP
126
LEG
128
130
132
134
SET RESET
136
EVENT
138

FIG. 4

FIG. 3


DOOR SENSORS
94
HVAC SENSORS
96
PARKING BRAKE SENSORS
98
COOLANT LEVEL SENSOR
100
WIPER FLUID SENSOR
102
TURN SIGNALS
104
A/D CONVERTERS
106
110
TO DATA LOGGING UNIT
90
KEYPAD
DISPLAY DEVICE
92
82
MEMORY
ROM
88
EEPROM
86
80
CPU
PORT INTERFACE
84
40
108
BUZZER

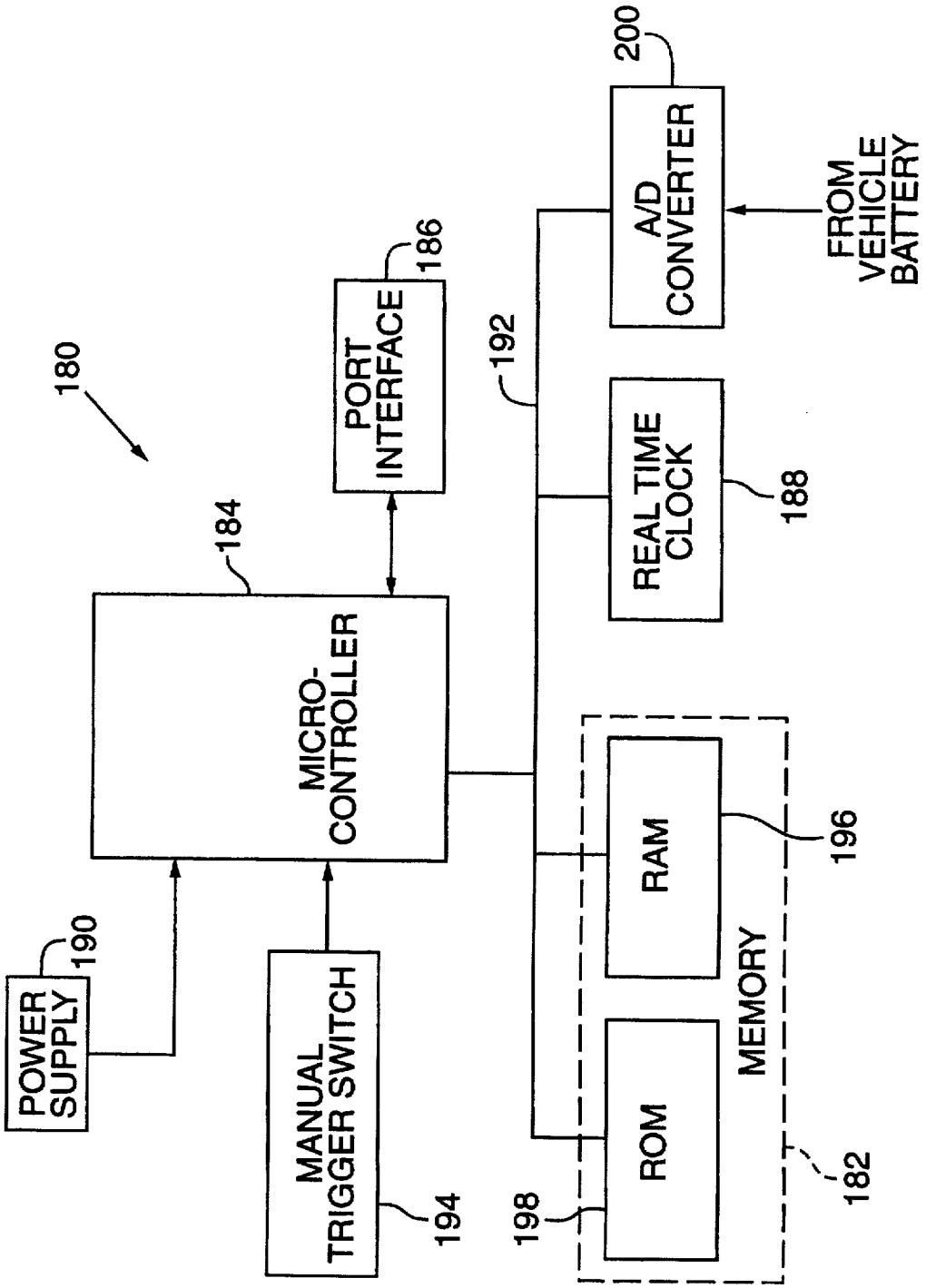

180
184
MICRO-CONTROLLER
PORT INTERFACE
186
192
A/D CONVERTER
200
FROM VEHICLE BATTERY
REAL TIME CLOCK
188
RAM
196
MEMORY
ROM
182
198
POWER SUPPLY
190
MANUAL TRIGGER SWITCH
194

FIG. 5

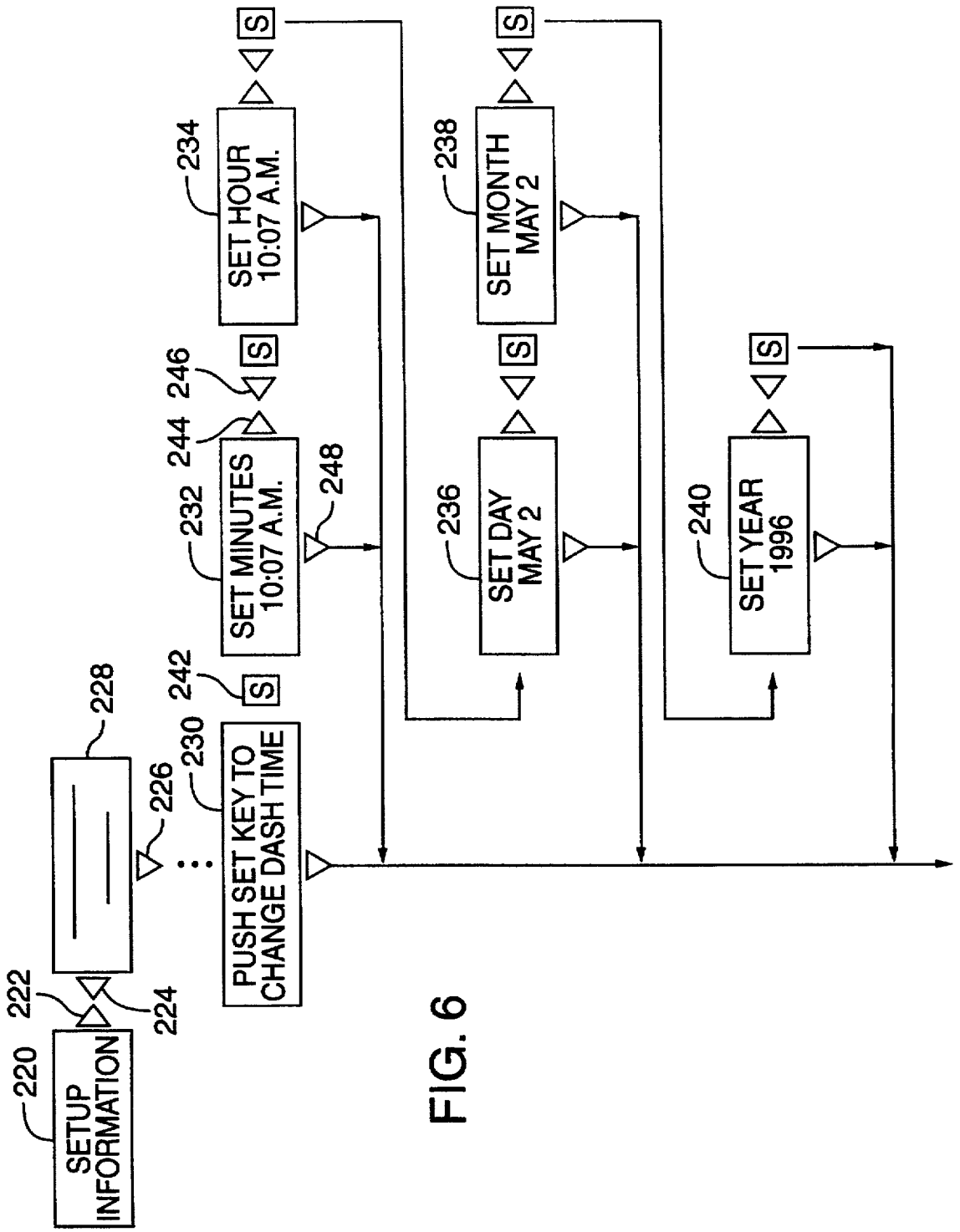

SETUP INFORMATION
220
222
224
226
228
PUSH SET KEY TO CHANGE DASH TIME
230
242
S
SET MINUTES 10:07 A.M.
232
244
246
248
S
SET HOUR 10:07 A.M.
234
S
SET DAY MAY 2
236
S
SET MONTH MAY 2
238
S
SET YEAR 1996
240
S

FIG. 6

FIG. 7A

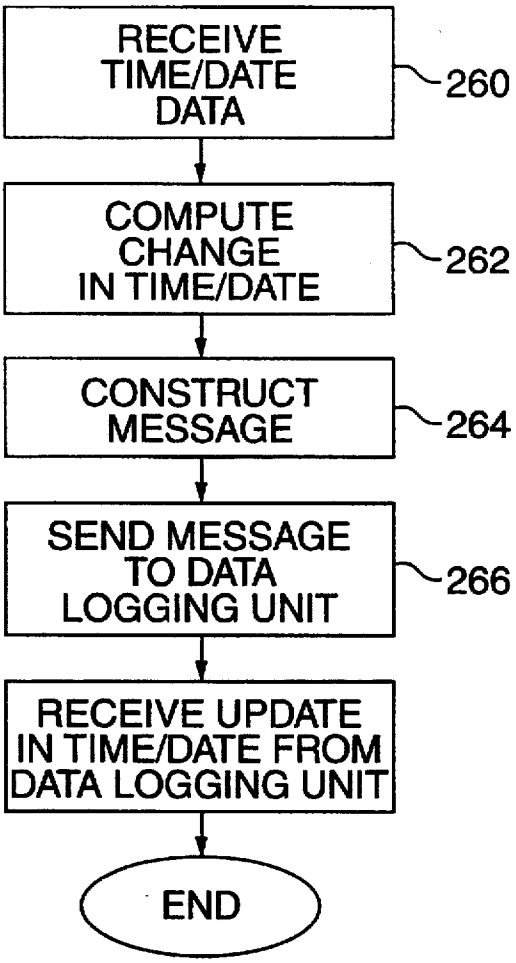

RECEIVE TIME/DATE DATA
260
COMPUTE CHANGE IN TIME/DATE
262
CONSTRUCT MESSAGE
264
SEND MESSAGE TO DATA LOGGING UNIT
266
RECEIVE UPDATE IN TIME/DATE FROM DATA LOGGING UNIT
END

FIG. 7B

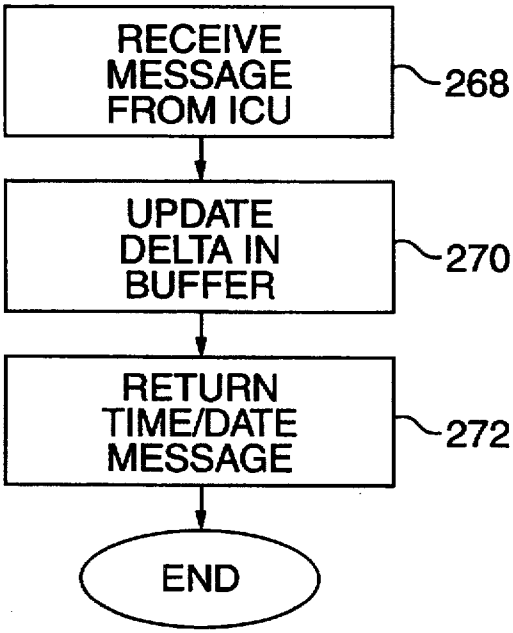

RECEIVE MESSAGE FROM ICU
268
UPDATE DELTA IN BUFFER
270
RETURN TIME/DATE MESSAGE
272
END

FIG. 8A

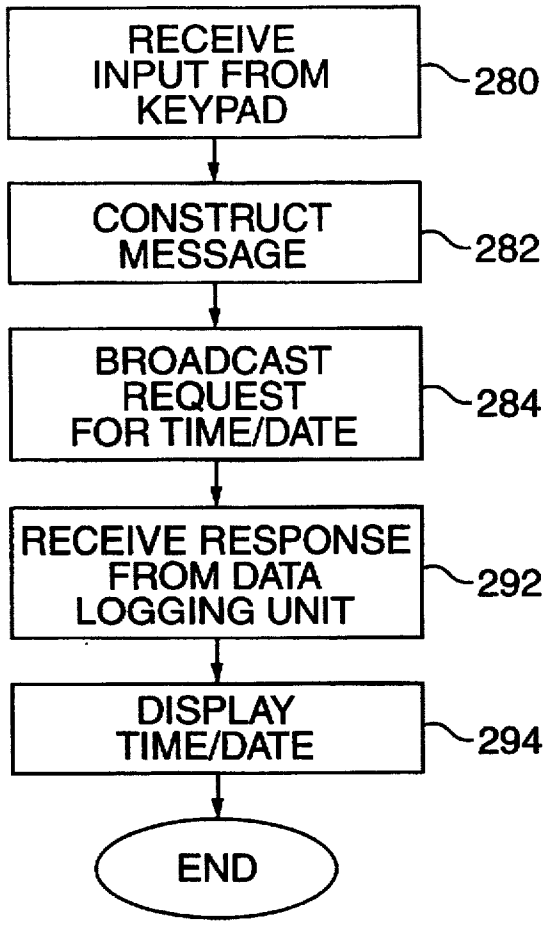
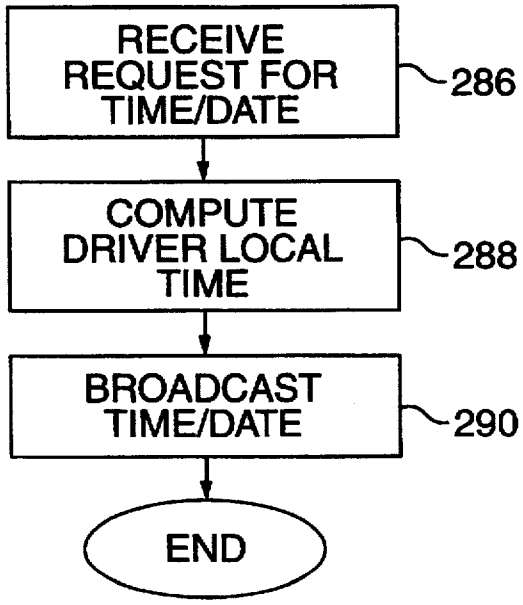

RECEIVE INPUT FROM KEYPAD
280
CONSTRUCT MESSAGE
282
BROADCAST REQUEST FOR TIME/DATE
284
RECEIVE RESPONSE FROM DATA LOGGING UNIT
292
DISPLAY TIME/DATE
294
END

FIG. 8B


RECEIVE REQUEST FOR TIME/DATE
286
COMPUTE DRIVER LOCAL TIME
288
BROADCAST TIME/DATE
290
END

METHOD AND SYSTEM FOR RECORDING VEHICLE DATA RELATIVE TO VEHICLE STANDARD TIME

The invention relates generally to data management and storage systems for vehicles, and more specifically relates to a vehicle clock capable of maintaining standard vehicle time and a driver local time.

BACKGROUND OF THE INVENTION

In the trucking industry, it is important to accurately maintain time for the benefit of both the driver and for service technicians. Since a truck driver frequently travels across time zones, it is helpful to provide a clock in the cabin that is easy to change with the change in time zones. In view of this fact, it is quite common for trucks to have clocks in the cabin that display time and can be reset to the local time. Aside from the convenience to the driver, it is also useful to have a clock for keeping track of vehicle operating and diagnostic data. For example, if a problem occurs in the transmission, it is useful to know precisely when the problem occurred. Many of the sophisticated electronic controls in trucks do have a mechanism for keeping track of time. Despite the presence of these electronics on board the truck, the frequent changes in local time and/or the lack of a consistency among time keepers in the vehicle often leads to confusion in identifying when problems on the truck actually occurred.

This confusion arises, for example, when a driver tells the service technician that a problem occurred at one time and the problem actually occurred at another time. This can result when an electronic subsystem in a truck records a fault using a time clock that is not consistent with the driver's time or time used by other subsystems in the vehicle.

It is equally confusing when a fault in a subsystem is recorded at one time in a first time zone and then is recorded again at the same time in a second time zone. Consider for example, a truck travelling west from South Bend, Ind. to Chicago, Ill. If faults are recorded in terms of local time, either by the driver or the truck's electronics, it is possible to record a fault at 2:00 P.M. in South Bend and a second fault at 2:00 P.M. in Chicago. The resulting data erroneously shows that the fault occurred twice at the same time, when in reality, they occurred one hour apart.

The problems outlined above occur because of the lack of effective means for displaying and keeping track of time in the truck. The difficulty in diagnosing problems in the vehicle are further frustrated by the lack of effective systems for tracking and recording faults detected in the truck. In general, there is a need for an effective system for tracking and recording events on a consistent basis and most preferably across all subsystems installed in a truck.

SUMMARY OF THE INVENTION

The invention provides a method for accurately recording vehicle performance data relative to a master or vehicle standard time and for conveniently displaying local time in the cabin of the vehicle. The invention further provides a master clock for maintaining vehicle standard time, and a system for recording vehicle data. In this context, vehicle standard time refers to a time reference or time standard in a truck against which the timing of performance data measured throughout the vehicle may be recorded. Vehicle standard time can also serve as a reference point for computing the local time displayed to the driver. Vehicle local time is variable and is typically adjusted by a driver as a time zone is passed. In one embodiment, a master clock maintains vehicle standard time, and also maintains driver local time. One specific way to maintain driver local time is to keep track of the difference between the local time and the vehicle time, and compute the local time, upon request, from the vehicle standard time and the difference value.

In one embodiment, a truck includes a data logging device for recording vehicle performance data relative to vehicle standard time. The data logging device monitors vehicle performance data such as road speed, engine speed, coolant temperature, etc. provided by data measuring devices throughout the vehicle. In the process of recording selected data, the data logging device stamps instances of the data with the vehicle standard time from a master vehicle clock. Time stamping refers to the process of associating vehicle standard time with the data. This master clock in this embodiment also maintains driver local time by keeping track of the difference between local time and vehicle standard time.

A local time display presents the local time in the cabin in the vehicle. If the driver wants to change the local time, he or she simply increments or decrements the time through an input control. Changes in local time are communicated to the master clock. In one specific implementation, the input control and time display are integrated into an instrument control unit. This instrument control unit communicates changes in local time to the master clock, which keeps track of the current difference between vehicle standard time and driver local time.

Further advantages and features of the invention will become apparent with reference to the following detailed description with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a functional block diagram illustrating a vehicle data recording system of an embodiment of the invention.

FIG. **2** is a block diagram illustrating the architecture of data management system on a vehicle.

FIG. **3** is a block diagram illustrating an embodiment of an instrument control unit in the data management system.

FIG. **4** is a diagram of the keypad of the instrument control unit shown in FIG. **3**.

FIG. **5** is block diagram illustrating the data logging unit in one embodiment of the invention.

FIG. **6** is a diagram illustrating one example of the display screens used to set or change driver local time.

FIGS. **7A** and **7B** are flow diagrams illustrating a process for setting the driver local time in one embodiment.

FIGS. **8A** and **8B** are flow diagrams illustrating the process for displaying local time in one embodiment.

DETAILED DESCRIPTION

FIG. **1** is a functional block diagram illustrating a vehicle data recording system of an embodiment of the invention. The system includes a plurality of data measuring devices (e.g. **20**, **22**, or **24**) for measuring vehicle performance data. Vehicle performance data can include a variety of vehicle operating, trip, maintenance or diagnostic data such as oil pressure, road speed, fuel rate, coolant level, coolant temperature, battery voltage, odometer etc. In addition, such vehicle performance data can include fault data such as oil pressure low, coolant temperature high, high intake manifold air temperature, electrical system or subsystem failure, etc. The vehicle performance data can be measured indirectly via

sensors controlled by electronic control units, or directly via discrete sensors or input devices. The data logging device **26** monitors vehicle performance data and potentially records selected instances or "slices" of this data. As alluded to above, the data logging device can receive the vehicle performance data either directly from a data measuring device such as a discrete sensor or input device, or indirectly through messages from electronic control units on a data link. For example, sensors can include a coolant level sensor, a battery voltage sensor, an input device located in the cab of the truck etc. Similarly, the data logging device **26** can be coupled to one or more electronic control units that measure performance data and transfer it to the data logging device via a data link.

The data logging device **26** can be programmed to record selected vehicle performance data in response to events. An event can be a fault detected in the vehicle such as coolant level low or electrical subsystem failure. In addition, an event can be a manually triggered signal or data message sent to the data logging device. For instance in one specific embodiment described further below, one type of event is a manually triggered event initiated by the driver. When used in conjunction with the time tracking devices in the system, this type of event is useful for tracking precisely when the driver experiences problems.

The master clock **28** is a time keeping device that maintains vehicle standard time on the truck. Vehicle standard time refers to a shared time resource or reference that monotonically increases from a starting time, and acts as a time reference for instances of vehicle data and events. The master clock can be located in a variety of locations in the truck. For instance, it can function as a stand alone device or can be incorporated into the data logging device **26**, or other electronic control device in the vehicle such as an engine computer or an instrument control unit in the cabin. In one embodiment, the master clock communicates vehicle standard time to the data logging device so that the data logging device can record the performance data relative to vehicle standard time.

In addition to keeping vehicle standard time, the master clock can also provide driver local time, which may or may not differ from the vehicle standard time. In one specific embodiment, the master clock maintains driver local time by storing the difference between driver local time and vehicle standard time.

The local time display **30** shown in FIG. **1** displays the driver local time in the cab of the truck. It can receive the local time either directly or indirectly from the master clock **28**. In one specific embodiment, the local time display receives the local time via the data logging device **26**.

The input control **32** enables the driver to control the display of driver local time. Located in the cabin of the truck, the input control enables the driver to increment or decrement the local time. For example, if the truck passes through a time zone, the driver can change the local time easily by simply pressing a button on the input control to change the local time displayed in the cabin. In one specific embodiment, changes in local time are communicated to the master clock, which maintains the current difference or "delta" between vehicle standard time and local time. More detail regarding a specific implementation of the system in FIG. **1** follows below.

FIG. **2** is a block diagram illustrating the system architecture in a more specific implementation of the system shown in FIG. **1**. The system architecture includes a number of electronic control units (ECUs) coupled together in with a data link **40**. In particular, the system includes an instrument control unit **42**, used to control instruments and gauges at the dash of the truck, and a data logging unit **44**, used to monitor and record events reported on the data link **40**. The illustrated system architecture also includes a number of other electronic units as shown, such as a powertrain ECU **46**, an air suspension ECU **48**, an antilock brake ECU **50**, and an air conditioning protection unit **52**. An ECU typically includes a microprocessor, memory and one or more sensors and actuators (**54**, **56**, **58**, **60**, **62** and **64** for example) used to control and/or monitor truck performance.

As one possible implementation, the devices depicted in FIG. **1** can be implemented in the system architecture shown in FIG. **2**. In one embodiment, for example, the data logging device and master clock are incorporated into the data logging unit **44**. The input control and the local time display are features of the instrument control unit **42**. Finally, the data measuring devices may correspond to the electronic control units. For instance, a data measuring device can be implemented in an electronic control unit, equipped with sensors for measuring vehicle performance data. As another example, a data measuring device can be implemented as a discrete sensor directly coupled to the data logging unit. More detail regarding the instrument control unit and data logging unit follows below.

The system architecture in FIG. **2** also includes a data port **70** for coupling external devices to the on-board data link. This data port **70** enables an external computer to receive and transmit messages on the data link. It also enables an external computer to establish a connection with an ECU on the network to either download data or retrieve data from memory of an ECU on the data link.

The data link **40**, in this implementation, is a serial communication path connecting the ECUs together. This particular data link is designed according to SAE J1708, a standard for serial data communication between microcomputer systems in heavy duty vehicle applications. While this specific embodiment is based on the J1708 standard, it is not critical that the invention be implemented in this specific manner. One possible alternative is to use a data link constructed according to SAE J1939.

In one specific embodiment, the data link **40** is comprised of a twisted pair cable operating at 9600 baud. Designed according to the SAE J1708 standard, the data link forms a communication channel among electronic control units coupled to it. Electronic control units generate a digital signal on the data link by applying a voltage differential between the two wires in the cable. A voltage differential above a specified threshold represents a logic high value, while a voltage threshold below a specified threshold represents a logic low value. This type of data link is particularly advantageous for hostile environments because the signal is more robust and impervious to signal degradation. However, other alternative communication media could be used in place of the J1708 cable.

The ECUs connected on the network communicate with each other according to protocols defined in SAE J1708 and SAE J1587. The SAE J1587 standard is entitled "Joint SAE/TMC Electronic Data Interchange Between Microcomputer Systems and Heavy Duty Vehicle Applications." This standard defines the format of data and messages communicated among microprocessors connected to a shared data link, and is specifically adapted for use with SAE J1708.

According to SAE J1708/J1587, the ECUs on the data link communicate by passing messages to each other. The

ECUs can be either receivers, or receivers and transmitters. In this particular implementation, the instrument control unit and the data logging unit are both transmitters and receivers.

A message includes the following: 1) a module ID (MID), 2) one or more parameters, and 3) a checksum. The number of parameters in a message is limited by the total message length defined in the SAE J1708 standard. The message identification numbers are assigned to transmitter categories as identified in SAE J1587. The MID portion of a message specifies the origin or transmitter of the message. In the majority of cases, messages are broadcast on the data link without specifying a receiver. However, the message format can be extended to include the MID of a receiver after the MID of the transmitter for special applications.

The messages passed among the ECUs to convey information by one or more parameters contained within the messages. According to the SAE J1587 standard, the first character of every parameter is a parameter identification character (PID). The parameter identified by the PID directly follows the PID. The SAE J1587 supports different data formats including a single character, a double data character or more than two data characters representing the parameter data. Several parameters can be packed into a message, limited by the maximum message size as noted above.

In this implementation, the ECUs communicate with each other over the data link according to the SAE standard J1708. The standard describes methods for accessing the data link and constructing messages for transfer over it. It also defines a method for resource contention among the ECUs on the data link.

An ECU wishing to transmit data on the data link first waits for a lull in transmission of data on the data link. In this particular implementation, the length of the lull is 200 milliseconds. After detecting this lull, the ECU attempts to transmit its message. The transmitter broadcasts its message onto the data link. Each of the ECUs that operate as receivers on the data link will receive the message. However, receivers only act on a message if programmed to do so.

In some cases two or more transmitters may attempt to broadcast a message at one time, giving rise to a collision. To resolve a conflict among transmitters, messages have a priority according to their message identifiers. The PIDs of higher priority parameters have a greater number of bits set at a logic level one. When more than one message is broadcast at a time, the more dominant message takes priority over lesser dominant messages. Since a lower priority message is blocked by a higher priority message, the transmitter of the lower priority message waits and retransmits the message after another lull. An ECU on the data link will continue to attempt to send a message until it is successfully broadcast to the data link.

While this particular embodiment is implemented according to the SAE J1708 standard, this is only one example a suitable data link implementation. Other alternatives are possible as well. For example, the data link can be implemented according to SAE J1939.

FIG. **3** is a block diagram illustrating the instrument control unit (ICU) in an embodiment of the invention. Preferably located at the dash of the truck, the instrument control unit can include the input control that enables a driver to display driver local time and to change the displayed time as well.

The instrument control unit includes a CPU **80**, memory **82** and a port interface **84** for connecting the unit to the data link **40**. The memory includes programmable ROM (EEPROM) **86** and permanent ROM **88**. The routines for controlling the ICU are stored in ROM **88**, while configurable data such as a configuration file is stored in the EEPROM **86**.

The ICU also includes an input device **90** and a display device **92**. In this implementation, the input device **90** is a ten key keypad, and the display device **92** presents a two-line display, sometimes referred to as the "message center." In one implementation, the display device comprises a two by 20 character vacuum fluorescent display. Alternative implementations are also possible such as a Liquid Crystal Display (LCD) or raster display device.

The ICU can be connected to a number of sensors (**94–104**) through analog to digital converters **106**. For example, the ICU in this implementation is coupled to: door sensors (**94**) for detecting when the cab doors are open or closed; HVAC sensors (**96**) for determining whether fresh air is circulating in the cab; parking brake controls (**98**) for sensing whether the parking brakes are applied; a coolant level sensor (**100**) for detecting when the coolant level drops below a specified level; wiper fluid sensors (**102**) for determining when the wiper fluid drops below a specified level; and turn signal controls (**104**) which indicate when a turn signal is applied.

The ICU can also include a buzzer **108** used to notify the driver when certain warning conditions are detected. Typical examples of these warning conditions include "cab door open," "parking brake applied and vehicle in motion," "coolant level low," etc. In this implementation, the buzzer is integrated into the ICU. However, a buzzer or other audio transducer can be implemented as a discrete device to the ICU.

The particular ICU used in this implementation is manufactured by Joseph Pollak of Boston, Mass. for Freightliner Corporation. The instrument control unit is available as a replacement part from Freightliner Corporation.

FIG. **4** is a diagram of one implementation of the keypad. The keypad includes the following dedicated keys:

1.	Time	(120)
2.	Temperature	(122)
3.	Fuel	(124)
4.	Trip (miles, hours and fuel)	(126)
5.	Leg (miles, hours and fuel)	(128)

The keypad also includes the following general purpose keys:

1.	Left Arrow Key	(130)
2.	Down Arrow Key	(132)
3.	Right Arrow Key	(134)
4.	Set/Reset Key	(136)

The keypad includes an event key **138** which enables the driver to specify that an event or problem has occurred with the vehicle. For example, if the driver is experiencing problems with the transmission, he can depress the event key to record data associated with the transmission problem. In response, the data logging unit **44** (FIG. **2**) receives an interrupt signal from the keypad **90** of the ICU (FIG. **3**) and creates an event file. In this implementation, there is a discrete connection **110** from the keypad **90** to the data logging unit **44**. In addition, the ICU can send a message to the data logging unit over the data link **40** to notify it that the driver or other user has triggered a manual event at the keypad **90**.

Using the keypad, a user such as the driver or other operator is able to display and set driver local time. In this

particular embodiment, the ICU displays driver local time in response to an input received from the "time" key in the keypad. Driver local time includes the time in hours and minutes (hh:mm A.M. or P.M.) and the date (month day, year). The time and date can be displayed at any time in response to the "time" key so long as the power to the dash of the truck is on.

To change or set the driver local time in this embodiment, the user presses a sequence of keys on the keypad to retrieve a set-up screen. For safety reasons, the set-up mode of the ICU can only be activated when the parking brake is applied. Further detail regarding setting and changing driver local time is provided below. Any available local time resetting approach may be used.

FIG. **5** is block diagram illustrating the data logging unit in one embodiment of the invention. In this implementation, the data logging unit incorporates the data logging device and master clock shown in FIG. **1**. The data logging unit **180** generally includes memory **182**, a microcontroller **184**, an interface **186** to the data link, a real time clock **188**, and a power supply **190**. The memory **182** and the real time clock are coupled to the microcontroller **184** via a bus **192**.

The power supply **190** includes a chip that supplies power to the microcontroller from either the vehicle battery or a lithium battery or other back up power supply. The lithium battery serves as a back-up in the event that the voltage supplied from the battery is insufficient or unavailable.

As noted above, the data logging unit is coupled to the keypad **90** of the ICU (FIG. **3**) to receive an interrupt when a user actuates the event key on the keypad. This connection is represented by the manual trigger switch **194** shown in FIG. **5**. The data logging unit can also receive interrupts from other devices as well. The keypad of the ICU could also be coupled to the data logging unit to communicate signals representing changes in driver local time. For example, a key or keys on the keypad could be configured to send signals to the data logging unit to update or modify local time, or the delta between vehicle standard time and local time, stored in the data logging unit.

The memory **182** of the data logging unit includes both RAM **196** and ROM **198**. This implementation includes 128KB of ROM, which stores the application code executed by the microcontroller. This executable code includes the set-up routines used to boot the data logging unit and the data logging routines used to monitor predefined events. This implementation also includes 256KB of battery-backed RAM, which is used to implement a FIFO buffer for capturing data from the data link, to store event files and to store a device parameter file.

The data logging unit can monitor vehicle performance data from the data link or from discrete sensors coupled directly to it. For example, the data logging unit monitors voltage supplied by the vehicle battery through an analog to digital converter **200**, which converts the 12 volt signal from the battery to a digital signal compatible with the microcontroller **184**.

The real time clock maintains vehicle standard or reference time. Though the driver local time may be reset, for example as the truck passes through time zones, the vehicle standard time does not change with changes in the local time. Instead, the vehicle standard time monotonically increases from an origin. Vehicle standard time is helpful in recording faults and events because it prevents ambiguity in tracking when these faults or events occurred relative to each other. Further detail regarding the operation of the master clock and the local time display is provided below.

As introduced above, the data logging unit performs a data monitoring function. Coupled to the data link, the data logging unit listens for periodic data messages broadcast over the data link, and continuously records a snapshot of data from the data link into a temporary storage device, such as a FIFO buffer. In this implementation, the data logging unit is programmed to continuously store the most recent 60 seconds of data from the data link. Instances of vehicle performance data can be captured at different intervals. For example, data can be captured once a minute, twice a minute, every second, or only when a predefined event is detected. Some examples of the data monitored by the data logging unit are set forth below. The name of the parameter is followed by the parameter identification number (PID) as set forth in the SAE J1587 standard.

Vehicle Road Speed; PID 84
Percent Throttle; PID 91
Percent Engine Load; PID 92
Output Torque; PID 93
Engine Oil Pressure; PID 100
Turbo Boost Pressure; PID 102
Coolant Temperature; PID 110
Engine Speed (RPM); PID 190

The data logging unit captures instances of selected data once every second and stores it in the buffer. When the buffer is full, the most recent second of data overwrites the oldest snapshot of data.

In addition to continuously storing slices of selected data, the data logging unit also monitors predefined events. These events can be defined by a PID broadcast on the data link, or by a discrete signal (such as an interrupt) received at the data logging unit. When one of the predefined events occurs, the data logging unit stores the last 60 seconds worth of data to memory and begins storing data following the event, such as the next 60 seconds worth of data. In total, the amount of data stored for an event includes two minutes and one second worth of data in this particular implementation. This data is recorded in an event file in memory. An external computer can be used to extract one or more of these event files from the data logging unit for diagnostic purposes.

As noted above, the system architecture on-board the vehicle maintains both vehicle standard time for tracking events and faults and driver local time for display to the driver. In the implementation described and illustrated above, the data logging unit maintains vehicle standard time and the difference (delta) between vehicle standard time and driver local time. In response to a request to display local time at the keypad, the ICU issues a request for the time. The data logging unit then returns the appropriate time to the ICU.

FIG. **6** is a diagram illustrating one example of the display screens used to set or change driver local time. This diagram shows a series of display screens as well as the keys on the keypad used to change screens and enter data. Starting with the setup screen **220**, the user accesses time/date setup screens by using the arrow keys (**222–226** for example) on the keypad as shown. The user begins by scrolling through setup screens **228** to reach the main time/date screen **230**.

When the user reaches the main time/date screen **230**, he or she can then set the minutes (**232**), hours (**234**), day (**236**), month (**238**) and year (**240**) using the set key **242** and left and right arrow keys **244**, **246**, for example. To exit the time/date screens, the user can press the down arrow key (**248** for example). FIG. **5** represents only one example of one implementation of a user interface for the ICU. A number of other approaches are possible as well.

FIGS. **7A** and **7B** are flow diagrams illustrating a process for setting the driver local time in one embodiment. FIG. **7A**

illustrates the steps executed by the ICU, and FIG. 7B illustrates the steps executed by the data logging unit.

The process begins when a user changes the time or date from the setup screens as described above. The ICU receives the data entered at the keypad when the user presses the set key (260). It then computes the change in time or date of the driver local time (262). The ICU then constructs a message to send to the data logging unit (264). Depending on what the user changes, a message or messages can be sent for the change in time, the change in date, or changes in both the time and date.

The specification for one implementation of the change in time is set forth below.

Delta Time Change

Priority:	8
Update Period:	As needed
Format:	MID_Cluster 254 MID_Datalogger Message_Length 31 Minute_Byte Hour_Byte Checksum

Where Minute_Byte and Hour_Byte are as defined below:

Byte	Type	Resolution	Valid Range
Minute	Signed Short Integer	1 minute/bit	−60 to +60 minutes
Hour	Signed Short Integer	1 hour/bit	−24 to +24 hours

Example:

140	254	179	3	31	01	00
	Checksum					

Example requests displayed time be incremented by one minute.

The specification for one implementation of the change in date is set forth below.

Delta Date Change

Priority:	8
Update Period:	As needed
Format:	MID_Cluster 254 MID_Datalogger Message_Length 30 Day_Byte Month_Byte Year_Byte Checksum

Where Day_Byte, Month_Byte, and Year_Byte are as defined below:

Byte	Type	Resolution	Valid Range
Day	Signed Short Integer	0.25 day/bit	−31.75 to +31.75 days
Month	Signed Short Integer	1 month/bit	−12 to +12 months
Year	Signed Short Integer	1 year/bit	−127 to +127 years

Example:

140	254	179	4	30	FC	00	00
	Checksum						

The Example shows the ICU sending a negative change of one day to the data logging unit date buffers.

As set forth in the above message specifications, the ICU sends the change in time and/or data to the data logging unit by specifying its MID (266). The data logging unit receives the message or messages from the ICU (268, FIG. 7B), and in response, updates values in a buffer for storing the difference (delta) between vehicle standard time and driver local time (270). In this particular implementation, the battery backed RAM in the data logging unit includes this memory buffer. The data logging unit adds a signed change in time to the cumulative time "delta" or "offset" stored in the buffer. Similarly for a change in date, it adds a signed change in date to the cumulative date value stored in the buffer.

As an alternative to communicating changes in local time over the data link, the keypad of the ICU can be directly connected to the data logging unit to transfer data representing changes in local time. In response, the data logging unit would then update the time/date buffer as described above.

After updating the buffer, the data logging unit sends a message, transferring the updated time or date to the ICU (272). In this particular implementation, the data logging unit issues a message using the J1587 standard parameters, PID 251 in the case of an update in time, or PID 252 in the case of an update of the date.

The specification for PIDs 251 and 252 used in this embodiment are set forth below.

PID 251 - Clock

Parameter Data Length:	3 Characters
Data Type:	Each Character - Unsigned Short Integer
Resolution:	Character 1 = 0.25 s/bit Character 2 = 1 min/bit Character 3 = 1 h/bit
Maximum Range:	Character 1 = 0 to 63.75 s Character 2 = 0 to 255 min Character 3 = 1 h/bit
Transmission Update Period:	On request
Message Priority:	8

Format:	PID	Data
	251	n a b c
	n	Number of parameter data characters = 3
	a	Seconds (not displayed in this implementation)
	b	Minutes
	c	Hours

PID 252 - Date

Parameter Data Length:	3 Characters
Data Type:	Each Character - Unsigned Short Integer
Resolution:	Character 1 = 0.25 day/bit Character 2 = 1 month/bit Character 3 = 1 year/bit
Maximum Range:	Character 1 = 0 to 63.75 day Character 2 = 0 to 255 month Character 3 = 0 to 255 year
Valid Range:	Character 1 = 0.25 to 31.75 day Character 2 = 1 to 12 month Character 3 = 0 to 255 year
Transmission Update Period:	On request
Message Priority:	8

Format:	PID	Data
	252	n a b c
	n	Number of parameter data characters = 3
	a	Day
	b	Month
	c	(Year - 1985)

A value of 0 for the date (Character 1) is null. The values 1, 2, 3 and 4 are used to identify the first day of the month; 5, 6, 7, and 8 identify the second day of the month etc.

A value of 0 for the month (Character 2) is null. The value 1 identifies January; 2 identifies February, etc.
A value of 0 for the year (Character 3) identifies the year 1985, a value of 1 identifies 1986, etc.

In response to the broadcast of the time or date update, the ICU retrieves and displays the current time and date (**274**). Although possible, preferably in this particular implementation the ICU does not maintain a separate clock for driver local time. Instead, it requests time as necessary from the data logging unit. However, it is also possible to maintain driver local time in the ICU. In an alternative implementation, the ICU could maintain the delta between local and vehicle standard time, and use the local delta value to compute driver local time.

FIGS. **8**A and **8**B are flow diagrams illustrating the process for displaying local time in one embodiment. FIG. **8**A illustrates the steps executed by the ICU to request time from the data logging unit, and FIG. **8**B illustrates the steps executing by the data logging unit in response to this request for time.

As shown in FIG. **8**A, the process begins when a user presses the time key on the keypad to request local time (**280**). In response to this input, the ICU constructs a message requesting the time and date (**282**). The message specifically includes the MID of the ICU, followed by PID 128 and the MID of the data logging unit, which represents a request for parameter transmission from the data logging unit. The message further includes PID 251 and 252 representing a request for the time and date, respectively.

The specification for PID 128 is forth in SAE J1587 and are provided below.

PID 128 - Component Specific Parameter Request-Used to request parameter data transmissions from a specified component on the data link.

Parameter Data Length:	2 Characters
Data Type:	Unsigned Short Integer (both characters)
Resolution:	Binary (both characters)
Maximum Range:	0 to 255 (both characters)
Transmission Update Period:	As needed
Message Priority:	8

Format:	PID	Data
	128	a b
	a	Parameter number of the requested parameter
	b	MID of the component from which the parameter data is requested

The ICU then broadcasts this message on the data link (**284**). As shown in FIG. **8**B, the data logging unit receives this message and begins to prepare a response (**286**). In this implementation, the data logging unit computes driver local time by adding the cumulative offset stored in the buffer to the vehicle standard time provided by the real time clock (**288**). Similarly, it computes the date to be displayed with driver local time by adding the cumulative offset for the date to the date provided by the real time clock (**288**).

After computing driver local time, the data logging unit constructs time and date messages and broadcasts them on the data link (**290**). The format of these messages adheres to the J1587 standard for PIDs 251 and 252 as set forth above.

Returning again to FIG. **8**A, the ICU is programmed to receive the time and data messages (**292**). It then reads the value for time and date provided in these messages and displays the time and date on the display device (**294**).

The approach described above enables the data processing system on the truck to monitor and record system-wide events and faults with respect to vehicle standard time, and to display correct driver local time.

While I have described the invention with reference to several specific embodiments, I do not intend to limit the scope of my invention to these specific embodiments. The master clock can be implemented in a variety of ways. It need not be incorporated into a data logging unit, but instead, could act as a stand alone device or could be incorporated into another ECU. The data logging device can be implemented in a variety of ways as well. It could be designed to monitor vehicle performance data through discrete sensors or through ECUs coupled to a shared data link, for example. The local time display and input control can be implemented in a variety of ways as well. For instance, they can implemented in an integrated dash control device such as the instrument control unit, or in discrete devices.

Having described and illustrated the principles of my invention with reference to a preferred embodiment and several variations thereon, it should be apparent that the invention can be modified in arrangement and detail without departing from its principles. Accordingly, I claim all modifications as may come within the scope and spirit of the following claims.

I claim:

1. A data recording system on a vehicle, the system comprising:

a plurality of vehicle data measuring devices operable to measure vehicle performance data;

a master vehicle clock operable to maintain vehicle standard time for the vehicle, and operable to maintain driver local time;

a data logging device communicative with a plurality of the vehicle data measuring devices and the master vehicle clock, the data logging unit being operable to monitor the vehicle performance data and to record selected vehicle performance data along with a time stamp in vehicle standard time from the master vehicle clock;

an input control communicative with the master vehicle clock, the input control being operable to receive user input to decrement or increment the driver local time, and operable to communicate a change in driver local time to the master vehicle clock;

a local time display communicative with the master vehicle clock, the local time display being operable to display the driver local time.

2. The system of claim **1** wherein the vehicle data measuring devices include an electronic control unit with at least one sensor for measuring vehicle performance data.

3. The system of claim **1** wherein the vehicle data measuring devices include at least one discrete sensor for measuring vehicle performance data.

4. The system of claim **1** wherein the vehicle data measuring devices include at least one electronic control unit coupled to the data logging device via a data link, and wherein the vehicle performance data includes parameters transferred to the data logging device by the at least one electronic control unit over the data link.

5. The system of claim **4** wherein data logging device is operable to record the selected vehicle performance data and time stamp in response to predefined events.

6. The system of claim **5** wherein the predefined events include a manually triggered event; wherein the input control is operable to receive user input indicating the manually triggered event, and the input control is communicative with the data logging device to communicate the manually triggered event to the data logging device.

7. The system of claim **6** wherein the data logging unit is operable to record selected vehicle performance data from

each of the plurality of vehicle measuring devices that has been communicated to the data logging device from the vehicle measuring devices over a period spanning before and after the manually triggered event.

8. The system of claim 5 wherein the predefined events include a fault detected by the at least one electronic control unit.

9. The system of claim 1 wherein the data logging device and the master vehicle clock are part of a data logging unit.

10. The system of claim 1 wherein the input control, and local time display are part of an instrument control unit coupled to the data logging device via a serial data link.

11. The system of claim 1 wherein the input control, and the local time display are part of an instrument control unit, wherein the data logging device and the master vehicle clock are part of a data logging unit, and wherein the instrument control unit communicates the change in local driver time to the data logging unit via a data link connecting the instrument control unit and the data logging unit.

12. In a vehicle including a data logging device for monitoring and recording events, a method for recording vehicle data relative to vehicle standard time and for maintaining driver local time for display in a cabin of the vehicle, the method comprising:

recording vehicle performance data relative to vehicle standard time by stamping slices of the vehicle performance data with the vehicle standard time from a master vehicle clock;

storing a delta value representing a difference between the vehicle standard time and a driver local time;

computing the driver local time from the delta value and the vehicle standard time;

displaying the driver local time in the cabin of the vehicle;

in response to a user request to decrement or increment the driver local time, updating the delta value to reflect the difference between the vehicle standard time and the driver local time;

monitoring for a manually triggered event entered into an input device in the vehicle:

in response to detecting the manually triggered event, storing the slices of vehicle performance data and time stamp over a predefined period that includes a time of occurrence of the manually triggered event.

13. The method of claim 12 wherein the step of recording vehicle performance data includes:

from the data logging device, monitoring a data link for faults transmitted by one or more electronic control units coupled to the data link and monitoring for the manually triggered event from the input device; and in response to detecting a first fault, storing the slices of vehicle performance data and time stamp over a predefined period that includes a time of occurrence of the first fault.

14. The method of claim 13 wherein the predefined period ranges from a time before the first fault to a time after the first fault such that the step of storing the slices of vehicle performance data includes storing a first set of slices of vehicle performance data occurring before the first fault and storing a second set of slices of vehicle performance data occurring after the first fault.

15. The method of claim 12 wherein the monitoring step includes monitoring for a message representing the manually triggered event transferred from an instrument control unit to the data logging device over a data link.

16. The method of claim 12 wherein the step of updating the delta value includes:

sending a message including a change in the local driver time to the data logging device; and

re-computing a new delta value from the stored delta value and the change in the local driver time.

17. The method of claim 12 wherein the step of updating the delta value includes:

communicating a change in the local driver time to the master vehicle clock;

and re-computing a new delta value from the stored delta value and the change in the local driver time.

18. A data recording system on a vehicle, the system comprising:

a data link;

a plurality of electronic control units including sensors for measuring vehicle performance data, and operable to transmit vehicle performance data on the data link;

the plurality of electronic control units including a data logging unit, and an instrument control unit;

the data logging unit comprising a real time clock operable to maintain vehicle standard time, and memory operable to store a delta value representing a difference between the vehicle standard time and driver local time, the data logging unit being responsive to each of the plurality of electronic control units for receiving vehicle parameters from each of the electronic control units and storing selected vehicle parameters along with a time indicator in vehicle standard time indicating a time of occurrence of the corresponding parameter; and

the instrument control unit comprising a display device, a keypad and a microprocessor, the display device being operable to display driver local time, the keypad operable to generate input signals representing an increment and a decrement in the driver local time and representing a manually triggered event, and the microprocessor being operable to receive the input signals and in response operable to communicate a change in driver local time and the manually triggered event to the data logging unit over the data link

wherein the data logging unit is operable to store the selected vehicle parameters from the electronic control units over a period of time that includes a time of occurrence of the manually triggered event in response to the manually triggered event from the instrument control unit.

19. A master vehicle clock in a truck comprising:

a real time clock operable to maintain vehicle standard time for at least two electronic control units in the truck;

a data logging device in communication with the electronic control units and the real time clock: the data logging device being operable to buffer vehicle performance parameters from the electronic control units and the data logging device being operable to write a set of the buffered vehicle performance parameters along with a vehicle standard time indicator to a file in response to a user input event, where the set of buffered vehicle performance parameters is defined by a moving period of time that includes a time of the user input event,

memory communicative with the real time clock, the memory operable to maintain a difference between the vehicle standard time and a driver local time;

local time display device communicative with the real time clock, the local display device being operable to display the local driver time in a cabin of the truck; and

an input control communicative with the real time clock, the input control being operable to receive input from a user representing a change in the driver local time, and operable to communicate the change to the real time clock.

20. A data recording system on a vehicle, the system comprising:

a plurality of vehicle data measuring devices operable to measure vehicle performance data from a plurality of vehicle subsystems;

a master clock maintaining a common vehicle standard time for said plurality of vehicle data measuring devices and generating time signals corresponding to vehicle standard time;

a data logging unit coupled to a plurality of the vehicle data measuring devices and to the master clock, the data logging unit recording the occurrence of predefined events detected by the data logging unit from data sent from the plurality of vehicle data measuring devices and detected from manually entered input during operation of the vehicle, the data logging unit also recording time stamps in association with the recorded events and a set of vehicle parameters sent from the vehicle data measuring devices within a predefined period of the occurrence of the recorded events, the time stamps being responsive to time signals from the master clock, whereby the time of an event relative to vehicle standard time is recorded for use in evaluating the event or diagnosing the cause of the event.

21. A data recording system according to claim **20** further including a computer selectively coupled to the data logging unit and operable to download and display the recorded events and time stamps for vehicle diagnostics.

22. A data recording system according to claim **21** further including a local time clock operable to display a variable local time.

23. A data recording system according to claim **22** in which the local time clock is coupled to the master clock with the local time being displayed in response to a difference signal representing the difference between the variable local time and the vehicle standard time.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 5,802,545
DATED : September 1, 1998
INVENTOR(S) : Cary N. Coverdill

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 13, claim 12,
Line 40, "vehicle:" should read -- vehicle; --.

Column 14, claim 19,
Line 52, "clock:" should read -- clock; --.
Line 61, "event," should read -- event; --.

Column 16, claim 22,
Line 13, "claim 21" should read -- claim 20 --.

Signed and Sealed this

Twenty-second Day of January, 2002

Attest:

Attesting Officer

JAMES E. ROGAN
Director of the United States Patent and Trademark Office